(12) UK Patent Application (19) GB (11) 2 095 470 A

(21) Application No **8201971**
(22) Date of filing **25 Jan 1982**
(30) Priority data
(31) **56/010431**
56/011138
(32) **26 Jan 1981**
27 Jan 1981
(33) **Japan (JP)**
(43) Application published
29 Sep 1982
(51) **INT CL^3**
H05B 33/02
(52) Domestic classification
H1K 1EA 2R3E 2S14A
2S21 2S27 4C11 5B1 EAL
(56) Documents cited
GB 1292544
GB 1019899
GB 1011384
GB 0997782
GB 0823783
(58) Field of search
H1K
(71) Applicants
Sharp Kabushiki Kaisha,
22-22 Nagaike-cho,
Abeno-ku,
Osaka 545,
Japan.
(72) Inventors
Etsuo Mizukami,
Yoshihiro Endo,
Yoshito Yamashita,
Hisashi Uede,
Hiroshi Kishishita,
Masashi Kawaguchi.
(74) Agents
R.G.C. Jenkins and Co.,
Chancery House,
53/64 Chancery Lane,
London, WC2A 1QU.

(54) **Thin-film electroluminescent display panel with a heat-resisting glass substrate**

(57) An electroluminescent element is supported by a heat-resisting substrate 1 which has a strain point sufficient for resisting the effect of heat treatment of the thin-film electroluminescent layer at a temperature of 600°C or more. Preferably, the substrate comprises alumino-borosilicate gloss having a strain point of about 650°C or more. The electroluminescent element comprises an electroluminescent layer 4 of ZnS:Mn between a pair of dielectric layers 3, 5 with electrodes 2, 6. The electroluminescent layer is heat treated before depositing the upper dielectric layer 5 and counter-electrode 6.

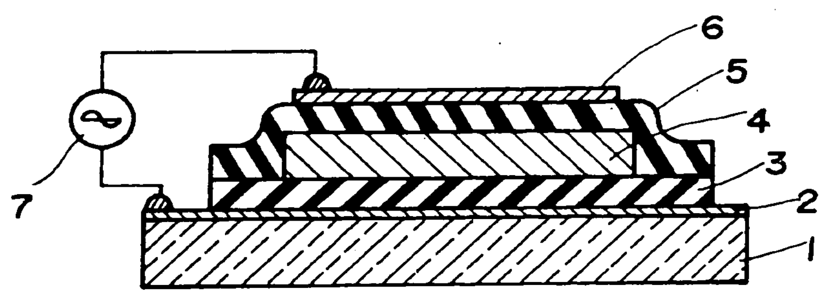

FIG. 1

The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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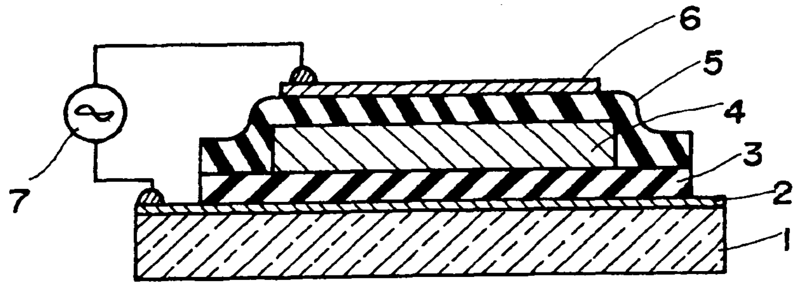

FIG. 1

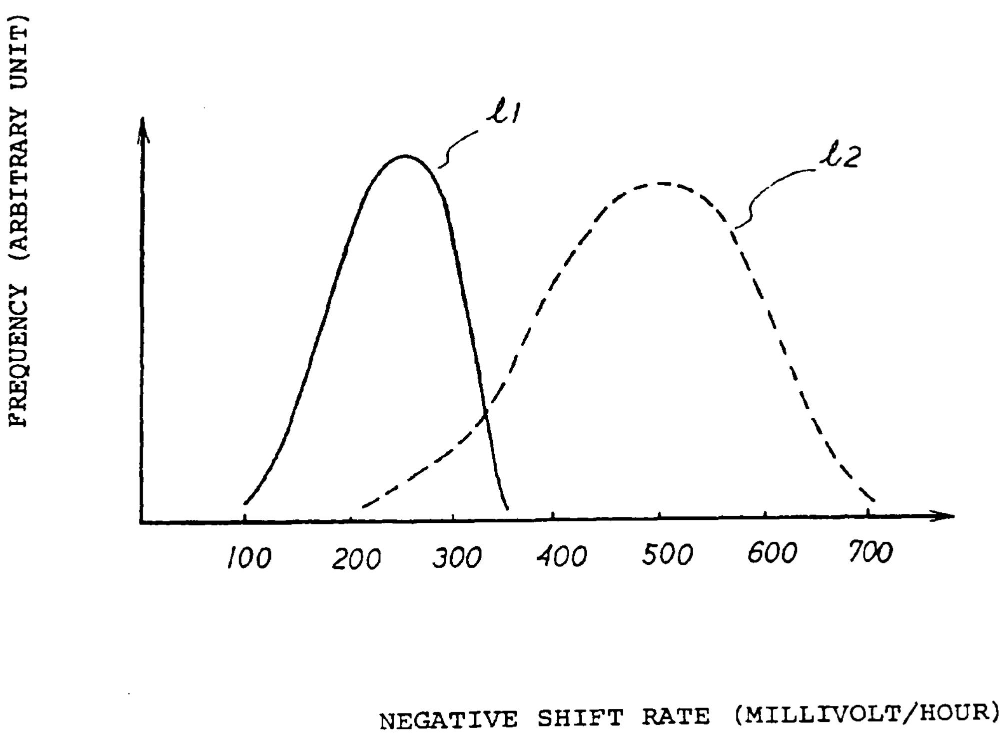

FIG.2

SPECIFICATION

Thin-film electroluminescent display panel with a heat-resisting glass substrate

Background of the invention

The present invention relates to a thin-film electroluminescent display panel and, more particularly, to a thin-film electroluminescent display panel with a heat-resisting glass substrate and a manufacture method thereof.

Firstly, a conventional electroluminescent display panel is illustrated in Figure 1, wherein the EL display panel comprises a first transparent glass substrate 1, a transparent electrode 2 made of In_2O_3, SnO_2 etc. formed thereon, a first dielectric layer 3 made of Y_2O_3, TiO_2, Si_3N_4, SiO_2, etc., an EL thin film 4 made of AnS:Mn, and a second dielectric layer 5 made of a similar material of the first dielectric layer 3. A counter electrode 6 is made of Al and is formed on the second dielectric layer 5 through evaporation techniques. The first dielectric layer 3 is provided by sputtering or electron beam evaporation techniques. The EL thin film 4 is made of a ZnS thin film doped with manganese at a desired amont. An AC electric field from an AC power source 7 is applied to the transporent electrode 2 and the counter electrode 6 to activate the EL thin film 4.

The EL thin film 4 is fabricated by electron beam evaporating a ZnS sintered pallet doped with Mn at a peferable quantity and, then, by heat-treating it in vacuum or an inert gas atmosphere. Mn serves as a luminescent center in the EL thin film 4.

Borosilicate glass has been suitable for the transparent glass substrate 1 because it is free of alkali and very flexible. It is produced and sold by Corning Glass Words (U.S.A.). As stated above, the EL thin film 4 on the first dielectric layer 3 is subject to heat treatment for improving crystalline and orientation of the film 4 after the electron beam evaporation. This heat treatment is to diffuse Mn as an activa element into ZnS and to replace Zn with Mn so as to provide strong chemical combination and orientation of ZnS substance. The conventional heat treatment is to heat the surface of the Borosilicate glass at about 540 - 570°C. Below this temperature range, suitable heat treatment effect can not be obtained so that the luminescence efficiency is very poor. Above this temperature range, a strain point of the conventional Borosilicate glass is exceeded. For example, the strain point is about 598°C in a specific Borosilicate glass, #7059 by corming Glass Works. The Borosilicate glass is widely distorted above the strain point during the heat treatment. The Borosilicate glass substance may react with the substances of the layers formed on the Borosilicate glass substrate to reduce the sustainable voltage by the electroluminescent display panel.

As stated above, AC pulses are used to drive the EL thin film 4. Actually, AC pulses having complicated rising pulses are applied to the film 4 so as to control positive and negative pulse amplitudes and their phases. Whenever at least one element of the amplitudes, the phases and the pulse risings is unbalanced, asymmetric pulses are developed which are used to drive the film 4. when the driving of the film 4 with the asymmetric pulses continues for a long time, a DC bias voltage owing to the deviated localization of the charges may be applied to the film 4. Therefore, nonbonding and free Zn atoms present in ZnS appear in the grain boundaries to damage the luminescent characteristics of the EL panel because the theshold voltage for enabling the same luminescence is lowered. This is called "negative-shift" phenomena herein. The negative-shift phenomena mean that the dark state can provide much luminescence more than the normal dark state of 1 ft-L (foot lambert) or less. Because, after a long period driving, the display contents can float, the display is seriously damaged.

Therefore, it is desired to remove the negative-shift phenomena.

Summary of the invention

Accordingly, it is an object of the present invention to provide an improved thin-film electroluminescent display panel in which negative shift phenomena are prevented from occuring.

It is another object of the present invention to provide a method for fabricating a thin-film electroluminescent display panel in which negative shift phenomena are prevented from occuring.

Briefly described, in accordance with the present invention, a thin-film electroluminescent element comprising a thin-film electroluminescent layer including an impurity serving as a luminescent center formed on a heat-resisting substrate for supporting the thin-film electroluminescent layer. The substrate has a strain point sufficient for resisting the effect of heat up to about 600°C or more to the thin-film electroluminescent layer in a nonoxidative atmosphere including vacuum and an inert gas. Preferably, the substrate comprises Aluminoborosilicate having the strain point of about 650°C or more.

Brief description of the drawings

The present invention will become more fully understood from the detailed description given hereinbelow and accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention and wherein:

Figure 1 shows a cross sectional view of a basic structure of a conventional EL display panel; and

Figure 2 shows a graph for representing a relation between heat treatment temperature and frequency of negative shift phenomena.

Description of the invention

The negative shift phenomena that the threshold voltage of the EL thin film 4 is lowered for providing the same luminescent intensity are due to the presence of nonbonding Zn atoms in the EL thin film 4. Therefore, the negative shift phenomena can be removed by accelerating the reaction of the Zn atoms so as to consume the nonbonding and free Zn atoms in the EL thin film 4 as much as possible.

For this purpose, a temperature of the heat treatment after the electron beam evaporation of the EL thin film 4 is raised according to the present invention so as to consume the non-bonding Zn atoms in the EL thin film 4.

A heat-resisting glass is provided for the transparent glass substrate 1 on which a plurality of layers as specifically described with reference to Figure 1 are formed. Preferably, an Aluminoboroslicate glass is selected as such a glass substrate. The Aluminoborosilicate glass belongs to the Borosilicate glass but has a raised temperature of the strain point of about 650°C or more since it contains alumina elements highly. One example of this type of glass is produced and sold by Hoya Electronics Co. Ltd. (Japan) as LE-30 having the strain point of 650°C.

On the Aluminoborosilicate glass substrate 1, the first di-electric layer 3 is layered on which the EL thin film 4 is formed by electron beam evaporation and, then, treated with heat of about 600°C in a nonoxidative atmosphere including vacuum and an inert gas. Thereafter, the display panel as shown in Figure 1 is fabricated by forming the second di-electric layer 5 and the counter electrode 6 on the EL thin film 4.

Figure 2 shows a graph for representing a relation between a temperature of the heat and frequency of the negative shift phenomena. In the graph, ℓ_1 is referred to data by the EL display panel in which the heat treatment temperature for the EL thin film 4 is about 600°C. ℓ_2 is referred to data by the EL display panel in which the heat treatment temperature for the EL thin film 4 is about 570°C. ℓ_1 is related to the present invention while ℓ_2 is related to the conventional case.

The abscissa in the graph of Figure 2 is a negative shift rate which is defined to be a rate of change in a threshold voltage for providing a particular luminescence in a unit time. Then, the negative shift rate is represented as follows:

$$\text{Negative shift rate} = \frac{dV \text{ (a changed voltage amount)}}{dt \text{ (a unit time)}}$$

As is apparent from the graph of Figure 2, the EL display panel comprising the EL thin film 4 which is heat-treated at about 600°C is improved by half or more than the EL display panel comprising the EL thin film 4 which is heat-treated at about 570°C, in respect to the negative shift rate and the distribution thereof. As the heat treatment temperature raises, the nonbonding and free Zn atoms can react more easily so as to consume the nonbonding and free Zn atoms. However, it is preferable that the heat treatment temperature is limited to be below about 650 - 700°C as far as a temperature at the strain point of the glass substrate 1 is higher than the heat treatment temperature.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications are intended to be included within the scope of the following claims.

CLAIMS

1. A thin-film electroluminescent element comprising:
a thin-film electroluminescent layer including an impurity serving as a luminescent center;
a pair of dielectric layers disposed so as to sandwich said thin-film electroluminescent layer;
electrodes provided on each of said dielectric layes; and
a heat-resisting substrate for supporting said thin-film electroluminescent layer, said pair of di-electric layers, and said electrodes;
the heat-resisting substrate having a strain point sufficient for resisting a heat treatment to the thin-film electroluminescent layer up to about 600°C or more.

2. The element of claim 1, wherein the heat-resisting substrate has the strain point sufficient for resisting the heat treatment to the thin-film electroluminescent layer up to about 600 - 700°C.

3. The element of claim 1, wherein the heat-resisting substrate comprises Aluminoborosilicate.

4. The element of claim 1, wherein the thin-film electro-luminescent layer comprises ZnS doped with Mn.

5. A method for fabricating a thin-film electroluminescent element comprising a thin-film electroluminescent layer including an impurity serving as a luminescent center, a pair of dielectric layers disposed so as to sandwich said thin-film electroluminescent layer, and electrodes provided on each of said dielectric layers, said method comprising:
positioning one of said electrodes and one of said pair of dielectric layers on a heat-resisting substrate;
forming said thin-film electroluminescent layer on said one of the electrodes and said one of the pair of dielectric layers; and
treating said thin-film electroluminescent lay r wit heat up t about 600°C or more in a nonoxidative

atmosphere;

the heat-resisting substrate having a strain point sufficient for resisting the heat treatment to said thin-film electroluminescent layer.

6. The method of claim 5, wherein the heat-resisting substrate has the strain point sufficient for resisting the heat treatment to said thin-film electroluminescent layer up to about 600 - 700°C.

7. The method of claim 5, wherein said heat-resisting substrate comprises Aluminoborosilicate.

8. The method of claim 5, wherein the nonoxidative atmosphere includes vacuum and an inert gas.

9. An electroluminescent element substantially as herein particularly described.

10. A method for fabricating an electroluminescent element substantially as herein particularly described.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1982.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.